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ABSTRACT

This paper describes the PICCO (PICtorial-COmputer) project the aim of which has been to study the development of the children's conceptual models and exploration strategies in the PICCO environment. The phenomenon, which was selected for the pictorial computer simulation, PICCO, was the variations of sunlight and the heat of the sun as experienced on earth related to the positions of the Earth and the Sun in space. The research experiments carried out in school and in day care centers, has found that children's exploration of the selected phenomenon using PICCO has supported the formation of children's conceptual models of the phenomenon in the direction of the currently accepted scientific knowledge. The results were discovered both in the situations where children explored the phenomenon using PICCO spontaneously without teaching and at school where children were taught at the same time about these phenomena. The new research is important because the earlier results brought out challenging and new findings especially concerning conceptual change in children's conceptual models of the astronomical phenomena. Future research will compare results especially with the theoretical model described in the author's earlier research and will take into account new aspects and perspectives. The PICCO project generates important theoretical knowledge for children's explorative learning, which is one of the most important skills for efficient lifelong learning. (Contains 22 references.) (Author)

PICCO -PROJECT

PAST AND FUTURE

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Abstract. This paper describes the PICCO project the aim of which has been to study the development of the children's conceptual models and exploration strategies in the PICCO environment. The phenomenon which was selected for the pictorial computer simulation, PICCO, was the variations of sunlight and the heat of the sun as experienced on earth related to the positions of the Earth and the Sun in space. In the research experiments at school and in day care centres there has been found out that children's exploration of the selected phenomenon using PICCO has supported the formation of children's conceptual models of the phenomenon in the direction of the currently accepted scientific knowledge. The results have been discovered both in the situations where children explored the phenomenon using PICCO spontaneously without teaching and at school where children have got at the same time teaching about these phenomena. The new research is important because the earlier results has brought out challenging and new findings concerning especially conceptual change in children's conceptual models of the astronomical phenomena. The future research will compare results especially with the theoretical model described in the author's earlier research and taking account the new aspects and perspectives into the investigation. The PICCO project generates important theoretical knowledge for children's explorative learning which is one of the most important skills for efficient lifelong learning.

1. Introduction

The paper describes the research whose aim has been to examine to what extent the children's independent and spontaneous use of the pictorial computer simulation, PICCO, could be of help in the developing and constructing of children's conceptual models of the selected phenomenon. And what kinds of methods and strategies children use when they are discovering and investigating the phenomenon by using PICCO? The chosen natural phenomenon for the pictorial computer simulation was the variations of sunlight and heat of the sun experienced on earth related to the positions of the Earth and the Sun in space. The research concerns 5-8 years old children. Research experiments have been carried out both in day care centres and at schools. In the research groups, there have been thirty three children. Eleven children used PICCO in a day care centre for four weeks independently and spontaneously. They had no formal instruction on the chosen natural phenomenon before or during the research period. Twenty two children explored the phenomenon using PICCO at a school where

children simultaneously had a teaching period concerning astronomical phenomena. The children's conceptual models were elicited before and after using PICCO.

2. Conceptual Model

The theoretical foundation for the concept of the conceptual model in this investigation is basically laid by theories and the set of concepts in cognitive psychology and cognitive science. A conceptual model is seen as a mental construct, which is developing during a child's cognitive action. A child's cognitive action like perception, remembering and thinking processes, as well as activities connected with them, are primary processes in the developing of a child's conceptual model concerning a given natural phenomenon. Correspondingly, the conceptual model of a given natural phenomenon forms a basis for a child's cognitive activities concerning the phenomenon in question. By means of a conceptual model even through visual images it is possible, for example, to examine a phenomenon, its objects and their qualities and spatial and temporal relations, both events taking place within the phenomenon, and also to follow the sequences of the events. In addition, a conceptual model makes it possible to explain and predict a phenomenon. (Compare Nickerson, Perkins, Smith 1985.) The more developed and integrated the conceptual model of a phenomenon, the better basis it gives to cognitive activities concerning the phenomenon in question. (See e.g., Kangassalo 1994a, 1997c.)

Regarding a certain entity, a concept in this research is seen as a potential set of representations activated from the memory, each of which has a high probability of being triggered by a given stimulus and of occurring together with the others (see Damasio 1989). A concept is an activated representation of the neural networks of the brain. It is a representation or the group of the representations by which a perceived or recalled entity is possible to be conceived and joined with a particular object. The activated representations give the features and dimensions embodied in the co-evoked representations from the basis of which conceiving, defining and naming the object are possible. The activated representations can represent information which is recorded in different sense modalities. Activated representations concerning a certain entity can change from time to time. This is, for example, because of recording new information in the memory or the changed situation where representations are activated. "Furthermore the range of representations that form the basis for a certain concept varies from individual to individual depending on the acquaintance with the object, the type of experience the perceiver has had in relation to the object, the value of the object to the perceiver, and so on" (Damasio 1989, 26).

Conceptual models by children were elicited before and after using PICCO. During the elicitation situations, the children modelled the phenomenon through the means of various tasks through action, pictorially and verbally. In both procedures, before and after the use of the pictorial computer simulation, attention was paid to the same points in the natural phenomenon and the same basic principles had been followed in the

planning of both procedures. Separate tasks differed from each other to a certain extent in each procedure.

In the elicitation of a conceptual model, attention was paid to the order, continuity and regularity of events of the natural phenomenon on the earth, the interconnections of the Earth and the Sun in space, and interrelations of phenomena on the earth and in space. In addition attention was paid to the size, form and distance between the Earth and the Sun. Tasks given to the children, by which the elicitation of a conceptual model was achieved, were directed to all the above mentioned parts of the phenomenon.

3. Exploration Strategies

The exploration of the phenomenon by children was based on children's own interest, which occurred spontaneously and independently without any adult involvement and at a school where children simultaneously had a teaching period concerning astronomical phenomena.

When a child explored the phenomenon by using the simulation, each press of the mouse was recorded in the computer's memory. Presses were recorded so that it was possible afterwards to recall, from the computer's memory, the children's exploration pathways and to see this for each child. On the screen a child's exploration pathway can be seen, press by press, as similar pictures occurred in the exploration situation. Children's exploration pathways were recorded from the computer's memory on to paper and a description technique was developed for them. The description technique makes it possible to follow the children's exploration process as it happened in the original situation. The description technique allows one to see on which levels of the phenomenon a child's exploration took place.

In examining children's exploration processes it is possible to see that exploration contains goal oriented and systematic action. Goals and the intensity of systematic action can vary, even during the same exploration situation. Exploration, which was possible to analyze and observe in children's action, included, in summary, the following: wandering, seeking for something, investigating, experimenting, finding amusement with space shuttle and making up tales.

4. Pictorial-Computer-Based Simulation - PICCO

The pictorial computer simulation - PICCO - concentrates on the variations of sunlight and heat of the sun as experienced on the earth related to the positions of the earth and the sun in space. In the simulation it is possible to explore the variations of sunlight and heat of the sun and their effects on the earth in a natural environment. It is also possible to examine the origin of these phenomena from the basis of the interconnections and positions of the earth and the sun in space. On the earth level the simulation concentrates on phenomena which are close to the everyday experiences of children, such as day and night, seasons, changes in the life of plants and birds etc. The simulation program has been implemented in such a way that the

knowledge structure and theory of the phenomenon are based on events appearing together with the phenomenon in question, and these events are illustrated. In the simulation all events and necessary elements are represented as pictures and familiar symbols. At the earth level the pictorial simulation represents the surrounding world, its phenomena and objects in a very natural and realistic way. In exploring the phenomenon at the space level the interrelations of the earth and the sun are represented with the help of an analogue model. PICCO has been aimed for 5 - 8 eight years old. It is very easy to use and it does not presuppose an ability to read or write. (See e.g., Kangassalo 1991, 1992, 1994b, 1997a, 1997c.)

5. Research Results

The children's conceptual models developed quite a lot during the exploration periods. After the use of PICCO, the most essential change that occurred in the children's conceptual models was that the interconnections of different aspects and phenomena began to be constructed. This construction seems to point in the direction of the currently accepted scientific knowledge. The extent of construction varied in children's conceptual models. In the construction of the interconnections of phenomena and entities the following phases could be distinguished:

- existence of interconnections had been discovered
- organization of interconnections took shape (order, continuity and regularities)
- number of interconnections increased
- reorganization of interconnections took shape: former interconnections ceased to exist and/or interconnections were replaced by other interconnections

Concerning the natural phenomenon chosen for this research, the main noticeable direction in the construction of the children's conceptual models, when using PICCO, tended to be as follows:

1. The Earth began to revolve around the Sun or to round or spin in one place on the Earth's orbit.
2. Seasons were organized in the surrounding world. Some connections on the earth and in space either the succession of the seasons or the alternation of day and night could be seen connected with the position of the Earth and the Sun.
3. Seasons on the earth were connected to the positions of the Earth and the Sun in space. The alternation of lightness and darkness on the earth was seen to have resulted from the turning or revolving of the Earth in the Earth's orbit.
4. The alternation of lightness and darkness and the succession of seasons have been seen to have resulted from the rotation of the Earth around its axis once every 24 hours while the Earth revolved around the Sun, a circuit around the Sun taking place once a year.
5. In conceptual models in which before the use of the simulation the Sun revolved around the Earth after the use of the simulation, the Sun no longer revolved around the Earth. In these cases the earth could spin in one place

on its orbit or revolve around the Sun. The change that took place in the conceptual model of an individual child contained conceptual change to a different extent and depth. (Kangassalo 1993, 1994b, 1997b, 1997c, 1998.)

In comparing the results between the group where children explored the phenomenon using PICCO independently and spontaneously without any teaching with the results and the group where children could receive teaching about these phenomena some very interesting and challenging differences could be seen. The main differences concerned the integration of the alternation of lightness and darkness, and the succession of seasons on Earth in the relationship between the Earth and Sun. The children who received teaching seemed to have more difficulties in this integration process compared with the children who explored the phenomenon independently using PICCO. In the conceptual models of the children, who independently explored the phenomenon using PICCO, first the succession of the seasons in the relation of the Earth and the Sun were discovered. After that the children started to integrate the alternation of day and night on the earth with the relations of the Earth and the Sun in space. While the children who got teaching tried to solve these questions together and that is why there existed more difficulties on this integration process.

According to previous results it seems possible that an independent exploration through the means of PICCO at a very early stage, when children are spontaneously interested in such things, could help them in the formation of a correctly directed conceptual model of this phenomenon. These results are important and significant of interest. This is because previous research concerning the conceptual development in astronomy has suggested that children proceed during their knowledge acquisition towards the scientific knowledge through many kinds of misconceptions. Further, the abandonment of the misconceptions has proved to be very difficult. (E.g., Vosniadou 1991, 1994; Vosniadou and Brewer 1992, 1994.)

6. Future Research

The future research will compare results especially with the theoretical model described in the author's earlier research and taking account the new aspects and perspectives into the investigation. In this forthcoming research project the development of children's conceptual models, exploration strategies and children's social interaction in the PICCO environment will be studied. The aim of the forthcoming research project is to develop a general model of the conceptual change in children's conceptual models and the development of children's exploration strategies in the PICCO environment taking into account cognitive processes, situated cognition (see e.g., Resnick 1996) and, later, cultural context. The investigation will be divided into two areas. Research which will be concentrated on studying the use of the PICCO program as a tool of a child's independent and spontaneous exploration in a day care centre and the PICCO program as a support for learning and teaching in a school environment with different age groups. (Kangassalo 1999a.)

With the help of Figure 1 it is possible to illustrate the future research. In this context, particular importance in the forthcoming research will be to emphasize the cognitive and social dynamics of interaction in the PICCO environment and to examine their association with the development of children's conceptual understanding and exploration strategies within this learning context.

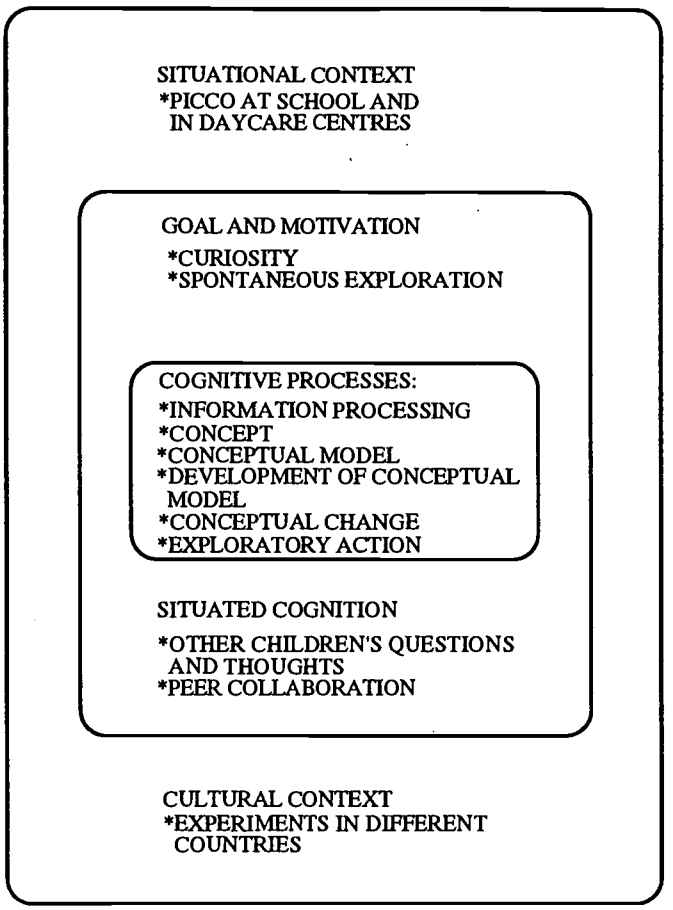

Figure 1. Main aspects of the future research

In these forthcoming research experiments it is possible to use the new version of PICCO which contains some new features in comparison with the earlier version. The new version is colorful, has brief explanations, for example the names of birds and flowers can be heard and read on the screen. Additionally, some new parts for the space level in the program have been taken into account. (Kangassalo 1999b.)

The data collection methods necessary for the analysis of interaction in the PICCO environment includes: observations and video-records of children's activity in a PICCO environment, transcriptions of social interaction, interviews to examine participants' orientations and interpretations of their activity in the PICCO environment. The assessment of children's conceptual models concerning the natural phenomenon in question will be done both before and after children's use of PICCO. The development of children's conceptual models and children's exploration strategies during their exploration through PICCO will be followed from the

basis of children's exploration paths which are recorded into a computer's memory.

In the research project cooperation will take place with Dr. Kristiina Kumpulainen of the University of Oulu and professor Ohsuga's laboratory at Waseda University, Tokyo. The PICCO project is to be integrated with the existing research of the collaboration members.

Kristiina Kumpulainen has done a great deal of valuable research in the area of social interaction (Kumpulainen 1996; Kumpulainen & Mutanen 1998, 1999). In this project, we will combine the aspects of cognitive processes and social interaction in the PICCO environment as an method to study the cognitive and social dynamics of interaction in the PICCO environment and to examine their association with the development of children's conceptual understanding and exploration strategies within this learning context. Moreover, Kristiina Kumpulainen will develop appropriate methodological tools to analyse social interaction in the PICCO environment.

Professor Ohsuga's laboratory at Waseda University, Tokyo, will cooperate with the PICCO project. The PICCO -project will serve as an example and test material for the developing and constructing of the new modeling method by Professor Ohsuga (see e.g., Ohsuga 1996).

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